

POSITION STATEMENT

It is policy of the Washington State Department of Health to support food irradiation as an additional method to increase the safety of foods. The department finds that scientific evidence supports the safe use of irradiation on many foods:

1. To reduce the numbers of pathogens (bacteria, viruses and parasites);
2. To retard spoilage microorganisms (molds, yeasts and bacteria); and
3. To delay sprouting or ripening.

The Department of Health recognizes the current definition – “*food irradiation is a food additive*” – as stated by the U.S. congress in 1958. However, we find that food irradiation is a process, to be viewed as similar to pasteurization, rather than as a food additive. The department supports continued research on safe applications of food irradiation technology as well as research in solving any problems identified with its use.

BACKGROUND OF FOOD IRRADIATION

History of Irradiation of Foods: Shortly after the discovery of X-ray radiation and radioactivity in the late 1800s, researchers found that exposure of food to this radiation could kill some of the bacteria in it. Following the end of World War II, the U.S. Army initiated increased research into the uses of food irradiation. The U.S. Department of Agriculture has conducted the majority of the subsequent research.

How Food Irradiation Works: Radiation is energy in transit either as electromagnetic waves or high-speed particles. The type of radiation used in modern processing of materials, including foods, is limited to high-energy gamma rays, X-rays, and accelerated electrons. These kinds of radiation are also referred to as ionizing radiation because their energy levels are high enough to dislodge electrons from atoms and molecules and to convert them to electrically charged particles called ions. Foods that have been irradiated do not become radioactive, just as teeth that are X-rayed do not become radioactive.

Gamma rays and X-rays (like radiowaves, microwaves, ultraviolet, and visible light rays) form part of the electromagnetic spectrum, occurring in the short wavelength, high-energy region of the spectrum. Gamma rays and X-rays have the same properties and effects on materials, their origin being the main difference between them. X-rays with varying energies are generated by electron interactions produced by machines. Gamma rays with specific energies come from the spontaneous disintegration of radionuclides. Naturally-occurring and man-made radionuclides, also called radioactive isotopes or radioisotopes, are unstable and emit radiation as they spontaneously disintegrate, or decay, to a stable state. The time taken by a radionuclide to decay to half the level of radioactivity originally present is known as its half-life, and is specific for each radionuclide of a particular element. The becquerel (Bq) is the unit of radioactivity

currently used, and equals one disintegration per second. An older unit still used today is the curie (Ci), which equals 3×10^{10} Bq.

Radiation dose is the quantity of radiation energy absorbed by a material (food) as it passes through the radiation field during processing. This dose is currently measured by a unit called the gray (Gy). In terms of energy relationships, one gray equals one joule of energy absorbed per kilogram of food being irradiated. In early work the unit was the rad (1 Gy=100 rads). International health and safety authorities have endorsed the safety of irradiation for all foods up to a dose level of 10,000 Gy, which equals 10 kilograys [kGy]. The U.S. Food and Drug Administration (FDA) also concluded that food “compromising no more than 0.01 percent of the daily diet [e.g., spices] and irradiated at 50 kGy or less also can be considered safe for human consumption” (FDA, 1981).

Only certain radiation sources are used in food irradiation. These are the radionuclides (e.g., cobalt-60); X-ray machines having a maximum energy of five million electron volts (MeV); or electron machines having a maximum energy of 10 MeV. The radionuclide used almost exclusively for the irradiation of food by gamma rays is cobalt-60, which has a half-life of 5.3 years, decaying to non-radioactive nickel.

Some machine-produced radiation is suitable for irradiating certain materials. High-energy electron beams can be produced from machines capable of accelerating electrons. Electrons cannot penetrate very far into food, compared with gamma or X-rays. X-rays of various energies are produced when a beam of accelerated electrons bombards a metallic target. Although X-rays have good penetrability into food, the present efficiency of conversion from electrons to X-rays is generally less than 10 percent.

An important point is that gamma, electrons, or X-ray radiation used at the levels authorized for food irradiation will not make the food radioactive. It is also important to note that all food has some amount of natural radioactivity already present and no process can effectively remove that amount from it.

FDA Approval of Food Irradiation: The U.S. Food and Drug Administration has regulatory authority over the uses of irradiation on food.

Under section 201(s) of the Federal Food, Drug, and Cosmetic Act (the act) [21 U.S.C. 321(s)], a source of radiation used to treat food is defined as a food additive. The term *food additive* means: any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and including any source of radiation intended for any such use).

FDA approved the first use of irradiation on a food product in 1963 when it allowed radiation-treated wheat and wheat flour to be marketed. In approving the use of radiation, FDA sets the maximum radiation dose the product can be exposed to, measured in kiloGray (kGy). The

following is a list of all approved uses of radiation on foods to date, the purpose for irradiating them, and the radiation dose allowed. (Source – FDA Consumer magazine, May-June 1998)

Food	Approved Use	Dose
Spices and dry vegetable seasoning	Decontaminates and controls insects and microorganisms	30 kGy
Dry or dehydrated enzyme preparations	Controls insects and microorganisms	10 kGy
All foods	Controls insects	1 kGy
Fresh foods	Delays maturation	1 kGy
Poultry	Controls disease-causing microorganisms	3 kGy
Red meat (such as beef, lamb and pork)	Controls spoilage and disease-causing microorganisms	4.5 kGy (fresh) 7 k Gy (frozen)

International Approval of Food Irradiation: Alongside traditional methods of processing and preserving food, the technology of food irradiation is gaining more and more attention around the world. In at least 39 countries, health and safety authorities have approved irradiation of more than 40 different foods. These approvals include spices, grains, chicken, fruits, and vegetables. Twenty-nine of these countries were using food irradiation as a process for commercial purposes as of 1995. Decisions in other countries have been influenced by the adoption in 1983 of a worldwide standard covering irradiated foods.

This standard was adopted by the Codex Alimentarius Commission, a joint body of the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) representing more than 130 countries. It is based on the findings of a Joint Expert Committee on Food Irradiation (JECFI) convened by the FAO, WHO, and International Atomic Energy Agency (IAEA). JECFI evaluated available data in 1969, 1976, and 1980. In 1980 it concluded that “the irradiation of any food commodity” up to an overall average dose of 10 kilogray “presents no toxicological hazard” and requires no further testing. It further stated that irradiation up to 10 kilogray “introduced no special nutritional or microbiological problems” in foods.

Others Who Endorse Food Irradiation: The American Medical Association (AMA) has adopted the following policy on food irradiation:

“It is the policy of the AMA to: (1) affirm food irradiation as a safe and effective process that increases the safety of food when applied according to governing regulations; (2) consider the value of food irradiation to be diminished unless it is incorporated into a comprehensive food safety program based on good manufacturing practices and proper food handling, processing, storage, and preparation techniques; (3) encourage the FDA and the U.S. Department of Agriculture to continue the requirement that all irradiated fruits, vegetables, meats, and seafood carry the international logo that has become recognized as indicating that the food has been subjected to gamma irradiation, ...”

The American Dietetic Association (ADA) has also accepted food irradiation as a way to enhance food safety.

FOOD SAFETY ISSUES

For food safety programs, whether domestic or international, to be successful in providing safe foods to consumers, potential hazards must be controlled from production on the farm and throughout the entire processing and distribution operations until the foods reach consumers. This involves many different entities both in private industry and government. Currently, many different control measures are in use to ensure food safety. These include proper animal husbandry practices on the farm; safe slaughter practices; proper processing of foods by the controls of good manufacturing practices and Hazard Analysis Critical Control Points (HACCP); adequate thermal processing and canning; milk and juice pasteurization; food irradiation; the appropriate use of food additives; and proper food handling techniques by those in the food service industry and by consumers. If all of the many entities understand the need for proper procedures and practice them, the result would be safe food with minimal risk of foodborne disease.

Food irradiation is a useful tool within a comprehensive food safety program. However, food irradiation is not a panacea, nor is any other single process used within the whole food safety system. Food irradiation has many effective uses in food processing but is not successful in others. Successful uses include slowing the ripening of some fruits and vegetables; inhibiting sprouting of potatoes, onions, and garlic; destroying insect pests; destroying spoilage microorganisms; and killing foodborne pathogens such as parasites (*Trichinella spiralis* and *Toxoplasma gondii*), bacteria (e.g., *E. coli* O157:H7, *Salmonella*, *Campylobacter* and *Yersinia*), and viruses.

Within current technology, not all foods can benefit from irradiation. Food irradiation cannot be used to treat dairy foods or eggs because of resulting adverse flavors. Some fruits or vegetables suffer from loss of texture or spoil more rapidly after being irradiated (i.e., pears, peaches, apples, citrus fruits, or lettuce). If all of the microorganisms of concern are killed, the food does not necessarily remain contamination-free forever. Recontamination can always occur after completion of the irradiation process. Proper transportation, temperature control, and food handling procedures are necessary to avoid subsequent contamination.

Destruction of Microorganisms: Monk, Beuchat, and Doyle, in an article published in the *Journal of Food Protection* in 1995, summarized the effects of food irradiation on foodborne microorganisms. This article, titled Irradiation Inactivation of Food-Borne Microorganisms, states that vegetative bacterial cells are the most sensitive to destruction by irradiation compared to spore-forming bacteria and viruses, which are considerably more resistant to irradiation. Spoilage bacteria vary in their sensitivity to irradiation, with *Pseudomonas putida* exhibiting extreme sensitivity. *Clostridium sporogenes*, *Moraxella spp.*, *Acinetobacter spp.*, and *Micrococcus radiodurans* all demonstrate extreme resistance to destruction by irradiation. The effectiveness of irradiation is also dependent upon many other factors, such as food pH, temperature, water activity content (Aw), and the nature of the radiation used in the process.

Unintended Consequences of Food Irradiation: When a food is irradiated, some unintended consequences may occur. These include formation of radiolytic products, formation of a selective environment, and the potential for producing counterfeit freshness in spoiled foods.

The process of food irradiation causes breakage of cellular DNA in pathogens, which results in injury and death to the cell, if severe enough. Irradiation causes the formation of *free radicals* and other *radiolytic products*. These *radiolytic products* are chemicals produced by decomposition of existing compounds during irradiation. The formation of *radiolytic products* that occur during irradiation can sometimes produce minute quantities of potential carcinogens, just as cooking can. It was initially believed by certain scientists that some of the chemicals produced during irradiation were unique. The name *unique radiolytic products* (URP's) was coined to describe these chemicals. It is currently believed that there are numerous radiolytic products formed but that all are also formed in other processes and are not unique to food irradiation. Several panels of scientific experts have reviewed this topic and all have agreed that radiolytic products do not pose a risk to consumers at approved levels of irradiation not exceeding 10 kilograys. However, since no long term human feeding studies have occurred, others remain skeptical.

By combining both food irradiation and vacuum packaging, spoilage organisms are suppressed effectively. Spoilage organisms normally greatly outnumber pathogenic ones. The growth of spoilage organisms and changes that they produce in food signal that a food has been subjected to temperature abuse and might be potentially harmful. If all spoilage organisms are controlled, but pathogens survive, then a *selective environment* is formed that could allow high numbers of dangerous bacteria to grow without the signal of spoilage suggesting improper temperature storage conditions had occurred. Of greatest concern is *C. botulinum*, especially type E that can grow at refrigeration temperatures of 40° F. Because botulism is such a severe disease, FDA has not approved the irradiation of fish or seafood.

Labeling: Without an inexpensive, readily-available test to determine if food has been irradiated, regulatory agencies cannot enforce the labeling laws. FDA is responsible for food labeling for all foods produced within the United States, except meat and poultry that are regulated by the U.S. Department of Agriculture (USDA). Either the USDA or the FDA, depending upon what types of food are involved, regulates imported foods. At the state level, the Washington State Department of Agriculture (WSDA) has primary labeling authority. It is currently difficult and expensive to test if a food has been irradiated or not. So the FDA, USDA, and WSDA will find it difficult to determine if labeling is required or accurate.

CONSUMER ISSUES

Sensory Changes From Food Irradiation: Food irradiation can markedly change the sensory attributes of a food. The taste, odor, and texture can all be changed by irradiation. The higher the dose of irradiation used, the more likely this is to occur. For this reason FDA has forbidden irradiating a food more than one time. Fats are particularly susceptible to changes in odor and flavor. Some foods gain *irradiation flavor following irradiation*, which is similar to scorching

and has been described as “goaty” or like a wet dog smell. It is doubtful that consumers would accept foods with adverse sensory attributes. The food processing industry has been able to resolve some of the issues relating to changes in the quality of foods by lowering processing temperatures to refrigeration or freezing levels and/or by excluding oxygen from foods to be processed with the use of vacuum packaging. However, the conditions that are best for retaining sensory qualities are the opposite of those that provide the best destruction of pathogenic bacteria. Best kills of pathogens are achieved at higher temperatures and in the presence of oxygen.

Nutrition of Irradiated Foods: Nutrition is an important issue to consumers. Food irradiation will lower levels of some critical nutrients, especially some vitamins. Macronutrients in the diet (fats, protein, and carbohydrates) are not significantly altered by food irradiation. Minerals (iron, phosphorus, or calcium) are also unaffected by irradiation. Vitamins may be affected significantly, especially vitamins A, B1, B6, B12, C, E, and beta-carotene. Thiamin (vitamin B1) is most sensitive to irradiation, with a 40 percent reduction at a dose of 4.5 kGy in frozen pork. It should be noted that pork is not the major source of thiamin in the diet of humans. Other processes like cooking, canning, or freezing may also affect the same critical nutrients. There is some evidence that, when both food irradiation and cooking occur together, their effects are additive and exceed the effects of either cooking or food irradiation alone. In general, more work needs to be done in this area, especially in the area of additive effects of food irradiation and cooking (or other common food preparation methods).

Counterfeit Freshness: Would unscrupulous food processors use irradiation to reduce or destroy bacteria in substandard, decaying foods, and then sell the food to unsuspecting consumers? This practice has been called *counterfeit freshness*. Food irradiation can be used to lower levels of bacteria to safe levels in fresh foods, as well as in spoiled foods. While food irradiation is appropriately used to improve food safety, it could also be used illegally to destroy spoilage organisms in an attempt to mask decomposed or temperature abused foods from detection. An instance of this type of deceitful intent occurred in Europe in the 1970s involving fish that were irradiated in an attempt to mask spoilage. Luckily, it appears that this type of fraudulent use of food irradiation is rare.

OCCUPATIONAL AND ENVIRONMENTAL SAFETY

The control of radiation in an industrial environment is achieved through coordination of regulatory agencies, safety professionals, management, and trained workers.

Worker and Public Safety Concerns: One of the risks at irradiation facilities is associated with the potential hazard of accidental worker exposure to ionizing radiation. Under normal operating conditions, all exposures of workers to radiation are prevented because the radiation source is shielded. Irradiators are designed with several levels of redundant protection to detect equipment malfunction and to protect personnel from accidental radiation exposure. Potentially hazardous areas are monitored and a system of interlocks prevents unauthorized entry into the radiation cell when the source is exposed. Worker safety further rests upon strict operating procedures and proper training. Since the plants are constructed with very heavy radiation

shielding (usually thick concrete walls and ceilings), the process presents no risk to the public outside the facility.

All radiation plants must undergo a detailed review before being licensed. In Washington, regulations require periodic inspection of facilities to ensure compliance with the terms of operating licenses.

During the 25 years irradiation has been in wide use, there have been a few major accidents worldwide at industrial irradiation facilities. Some of these accidents caused injury or death to the workers. All of these accidents happened because safety systems had been deliberately bypassed and proper control procedures had not been followed. None of these accidents endangered public health or the environment.

Despite these few accidents, the radiation processing industry has a very good safety record. Today, there are about 170 industrial gamma irradiation facilities operating worldwide, some of which process foods in addition to other types of products. Most irradiation facilities are used for processing only non-food items.

No radioactivity from a food irradiation facility can be released into the environment. It is impossible for a *meltdown* to occur in a gamma irradiator or for the radiation source to explode. The source of radiation energy used at irradiators cannot produce neutrons, which can make materials radioactive, so no *nuclear chain reaction* can occur at an irradiator. The walls of the irradiation cell through which the food passes, the machinery inside the cell, and the product being processed cannot become radioactive.

Transportation and Waste Concerns: Radioactive material required for irradiators is transported in lead-shielded steel casks. These are designed to meet national and international standards modeled upon the Regulations for Safe Transport of Radioactive Materials of the International Atomic Energy Agency, and approved by the US Department of Transportation. Large quantities of radioactive material are safely shipped all over the world to supply some 170 irradiators processing a variety of goods, mainly medical products. For example, from 1955 to early 1988 Canada shipped approximately 190 million curies of cobalt-60 in 870 separate shipments without any radiation hazard to the environment or release of radioactive materials. The same procedures used so successfully and safely to transport radioactive materials to existing irradiators will be used for transporting radioactive materials to any additional irradiators constructed for food processing. In the United States, there has never been a transportation accident involving radioactive material that has resulted in an overexposure of any member of the public.

Radioactive waste does not accumulate at irradiation facilities because no radioactivity is produced. Industrial machines used to generate X-rays or electron beams do not use radioactive material. At gamma irradiators, the radionuclide source is typically cobalt-60, which decays over time to non-radioactive nickel. The sources are removed from the irradiator when the radioactivity falls to a low level, usually between 6 percent and 12 percent of the initial level (this takes 16 to 21 years for cobalt-60). The core elements are then returned in an approved

shipping container to the supplier, who has the option of reactivating them in a nuclear reactor or storing them. Canada has calculated that all the cobalt-60 it supplied for use in 1988 (about 100 million curies) would require a storage space of about 1.25 cu. meters (44.1 cu. feet), roughly equivalent to the space occupied by a small desk.

The same procedure is followed when an irradiation plant closes down. The radiation sources can be acquired by another user or returned to the supplier, the machinery dismantled, and the building used for other purposes. There is no radiation hazard for the new occupants or the general public.

CONCLUSIONS

Food irradiation can be an effective tool in processing some foods or when used in addition to other existing techniques. The World Health Organization, the U.S. Food and Drug Administration, and other groups have approved the use of food irradiation in the United States and overseas. Proper labeling of foods is recommended, so consumers can make informed choices.

ADDITIONAL INFORMATION AND REFERENCES

Web Sites:

Links to external resources are provided as a public service and do not imply endorsement by the Washington State Department of Health.

World Health Organization – “Food Irradiation” --

<http://www.who.int/archives/inf-pr-1997/en/pr97-68.html>

Radiation Information Network’s “Food Irradiation” –

www.physics.isu.edu/radinf/food.htm

Food and Drug Administration “Irradiation: A Safe Measure for Safer Food” –

<http://www.fda.gov/opacom/catalog/irradbro.html>

P.J. Skerrett. MIT Technology Review. “Food Irradiation: Will It Keep the Doctor Away?” --

www.technologyreview.com/articles/skerrett1197.asp

Journals and Reports:

American Dietetic Association. “Position of the American Dietetic Association: Food Irradiation.” J Am Diet Assoc. 1996 Jan; 96(1): 69-72. Review.

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Resurreccion AVA, Galvez FCF, Fletcher SM, Misra SK. "Consumer Attitudes Toward Irradiated Food: Results of a New Study." Journal of Food Protection 1995; 58:193-6.

Regulations:

Nuclear Regulatory Commission (NRC). 10 CFR Part 36. "LICENSES AND RADIATION SAFETY REQUIREMENTS FOR IRRADIATORS".

Food and Drug Administration (FDA). 10 CFR 21

Washington Administrative Code (WAC) 246-220 through 246-235.

DOH Points of Contact:

Food Safety	Food Safety Program (360) 236-3330
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Radiation Safety	Radiation Protection Division (360) 236-3222
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